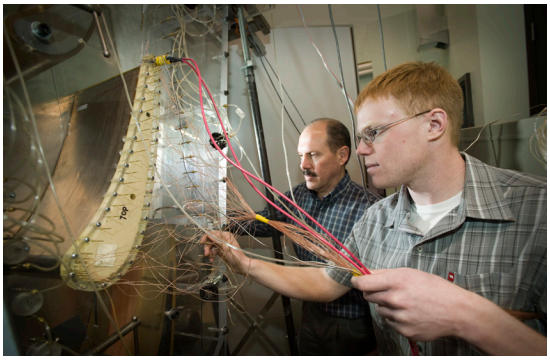
North Dakota

An Undiscovered Hotspot for Science- and Technology-based Development



A Strategic Plan for Science and Technology in North Dakota

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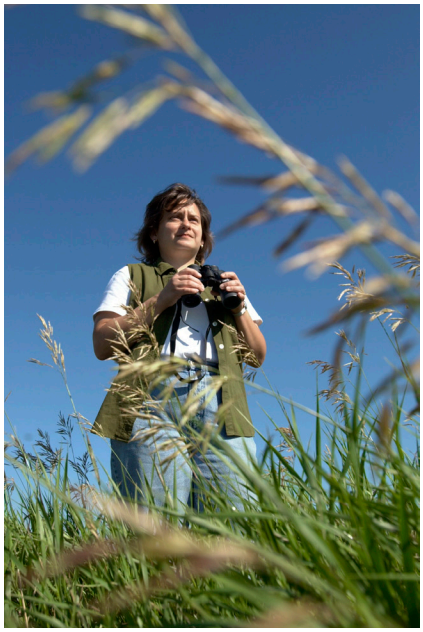
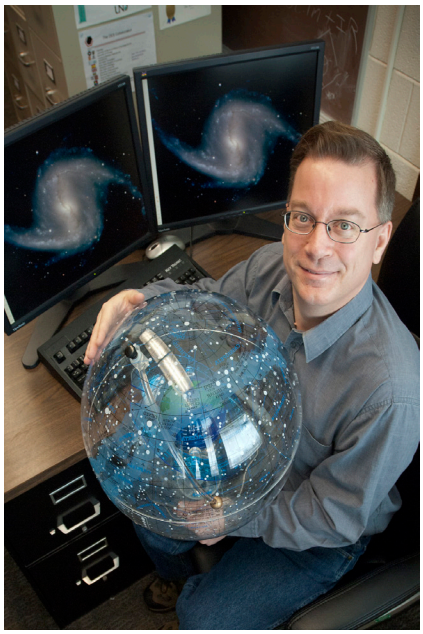
Introduction

In June 2012, the U.S. Chamber of Commerce's 2012 Enterprising States report characterized North Dakota as "an undiscovered hotspot for science- and technology-based development."[1] The report further noted that in addition to life sciences and vaccine research and development, the state is on the leading edge in microelectronics, manned/unmanned aviation, remote sensing, farm machinery and equipment, off-road vehicles, energy, agriculture, coatings and surfaces, and advanced manufacturing. North Dakota ranks second only to Massachusetts in the percentage of college-educated people younger than 44, and it ranks first among the states in the percentage of state and local contributions to university research.

During the past decade or more, the state's two largest universities — North Dakota State University NDSU) and the University of North Dakota (UND) — have undergone a transformation from institutions that focused primarily on teaching to becoming research universities. In that time, external funding for research at NDSU and UND has more than doubled, from $81.6 million in 2000 to $208 million in 2010. This external funding has an economic impact on the region of more than two dollars for every dollar brought in, and it is responsible for creation of several thousand jobs within the state each year.[2]

More recently, North Dakota has found itself significantly impacted by an oil boom in the Bakken formation; this boom differs from earlier oil plays in that successful wells are now the norm (97 percent), and recovery of oil, facilitated by new technology, is much greater than during the last expansion that occurred in the 1980s. Other energy resources in the state, including biofuels, wind power, and coal-fired generation plants, are also highly dependent on modern science and technology. The growth of life sciences research and business, especially in the Red River Valley, and increasing opportunities related to Unmanned Aircraft Systems/Remotely Piloted Aircraft (UAS/RPA), rely on cutting-edge science and technology for success and growth of economic development opportunities. Agriculture, which continues to be a mainstay of the North Dakota economy, significantly benefits from modern methods of crop and livestock genetics, breeding, nutrition, soil management and fertility, pest management, and remote sensing data for enhanced crop management.





North Dakota faces other issues that are highly dependent on scientific and engineering information resulting from research: managing floods of the Red River, Missouri River, and the Souris River; as well as chronically rising waters on Devils Lake and in the surrounding area.

The two research universities, UND and NDSU, also benefit the state's economy through commercialization of inventions made by faculty researchers, sometimes licensing them to existing entities and sometimes creating entirely new businesses within the state. Since 2002, the two universities have had 552 invention disclosures, 55 plant variety protection applications, and 65 patents issued, and have 156 patents pending. While NDSU has historically dominated in this arena, activity at UND has increased significantly since 2010, when the intellectual property office was revitalized.

Building partnerships with the private sector is pivotal to successful technology transfer outcomes. As a result of such research and development relationships, several companies have established new operations or expanded existing operations in North Dakota. In addition, several startups have formed as a result of research and development relationships and the licensing, or other related commercialization activities, involving technologies developed at North Dakota's research universities.

The North Dakota Economic Development Centers of Excellence program has been a driver in furthering technology-based economic development opportunities through public-private sector partnerships. Through this program, NDSU and UND engage with private-sector partners to further advance technologies and create new products that are driven by the needs of these partners. According to the 2011 COE Annual Report,[3] the program has created $538.8 million in estimated total economic impact to North Dakota, including a direct impact of $184.6 million generated by the Centers, grant recipients, and their partners.

All of these factors illustrate the need for North Dakota to have a strategic plan for science and technology in the state. Economic development in all sectors is dependent on modern science and engineering, and continued economic growth will be facilitated by smart planning and smart investments in science and technology, both within higher education and in other ways. Regulation of highly technical industries, as well as management of problems such as the Devils Lake area flooding, will be most effective if based on sound scientific information and policy advice to the Legislature and Governor. Moreover, North Dakota benefits from a program of the National Science Foundation (NSF) called EPSCoR (Experimental Program to Stimulate Competitive Research), which provides large ($20 million over five years) competitive grants to build research capacity in states that receive only small amounts of regular NSF funding. A statewide plan for science and technology will inform planning for the submission of the next EPSCoR proposal in late 2012. Funding from EPSCoR is managed jointly by NDSU and UND, but benefits all institutions of higher education in the North Dakota University System (NDUS) as well as the state's five tribal colleges. The Legislature has recognized the importance of EPSCoR to the state by consistently appropriating matching dollars ($7 million in 2011-13 biennium) since North Dakota first received EPSCoR funding in 1985.

North Dakota is currently engaged in ND 2020, a major visioning and strategic planning process for economic development in the state, sponsored by Governor Jack Dalrymple and the North Dakota Chamber of Commerce. This plan for science and technology will be an important part of the ND 2020 plan.

Existing State-Level Goals Related to Science and Technology

The North Dakota Department of Commerce has five major areas of emphasis for economic development,[4] shown in Table 1:

Table 1

North Dakota Department of Commerce Target Industries

- Advanced Manufacturing
- Energy
- Value-Added Agriculture
- Technology-Based Business
- Tourism

Of these areas, the first four clearly depend on science and technology. Even tourism, much of it focused on hunting and fishing, benefits from research that informs our management of wildlife and natural resources.

The North Dakota State University System has a strategic plan in which one of four goals relates to economic development, and much of it to research.[5] One of the Policy Focus Areas listed for this goal is "Expand research related to state needs." Table 2 lists the sub-goals that are relevant to science and technology.

A large number of state commissions support research, including the Agricultural Products Utilization Commission, Beef Commission, Wheat Commission, the Renewable Energy Council, the Oil and Gas Research Council, and the Water Commission.[6] The research goals of each group are defined by their responsibility. For example, the State Water Commission lists as a goal to "To conduct research into the processes affecting the hydrologic cycle to improve the management of

Table 2

Roundtable Cornerstone: Economic Development Connection

Goal 3: The North Dakota University System increases the overall vitality of the state through exceptional education, research, training, and service.

3.1	Increase completions in targeted, high-potential programs (agriculture, energy, health care, life sciences, advanced technology) by 5 percent.
3.3	North Dakota will rank first in the nation for the percentage of degrees and certificates awarded in Science, Technology, Engineering and Math (STEM) fields.
3.6	UND and NDSU research activities will, at a minimum, demonstrate overall progress on several research criteria based on an external evaluation including collaborations in and outside of North Dakota, patents, proposals, publications, and new faculty hires.
3.11	Demonstrate progress in knowledge transfer and commercialization through increased performance in the majority of defined metrics (IP licenses, licensing income, agreements, etc.).

North Dakota's water resources." The State Game and Fish Department contracts with universities and other entities for research related to its responsibilities to manage and regulate the taking of fish and game.

The North Dakota Economic Development Foundation, in its strategic plan for 2010-2020,[7] focuses on research as the second of five Essential Strategies for Continued Growth:

> *"Continue investing in university-based research and development conducted with the private sector that engages North Dakota in emerging industries such as life sciences and advanced technology."*

The EDF plan, in Goal 3, "Accelerate innovation and entrepreneurship in targeted industries and emerging technologies," lists research as a strategy to accomplish the goal:

> *"Support state programs for research, development, demonstration and commercialization of new technologies including the development of technology parks and incubators."*

Goal 4 of the EDF plan, "Enhance the state education and training system's ability to meet business and workforce needs of the future," also includes a strategy related to research:

> *"Better leverage the resources of the state's entire education system to support long-term economic development through education, training, and research."*

Recently, USDA Rural Development and others sponsored a statewide visioning exercise called North Dakota 2.0. A featured quotation in that report, from a Dickinson participant, asserts, "We must invest in scientific research and development to make everything else happen. We now have the ability to do this."[8]

In 2010, the Red River Valley Research Corridor was highlighted by Inc magazine as one of the top 20 emerging areas in the United States for research on vaccines and infectious diseases. Very recently, prominent Fargo businessman Bill Marcil challenged the two research universities, together with the cities of Fargo and Grand Forks, to develop a strategic plan for technology-based economic development in the Red River Valley corridor.[9]

Overall, it appears that diverse groups have recognized the importance of science and technology, including research, to the economic health of the state. This plan brings all of these ideas together in one document.

Current Leading Indicators for North Dakota Science and Technology

The U.S. Chamber of Commerce's 2012 Enterprising States report[10] ranks North Dakota as the nation's No. 1 performing economy for jobs, productivity, and income. The state was No. 1 in STEM job growth (Science, Technology, Engineering, and Math) from 2001-2011, and fifth overall from 2009-2011, with 5.4 percent STEM job growth in two years. However, the actual number of STEM jobs in North Dakota was only about 13,000, approximately 3.3 percent of all jobs in the state10. Leading sectors for job growth in North Dakota from 2001-2011 were Mining, Quarrying, and Oil and Gas Extraction (13,902 jobs, the largest growth sector); and Professional, Scientific, and Technical Services (6,102 jobs), the fourth-largest growth sector. Both sectors provide many science- and technology-related jobs.

The Enterprising States report also ranked North Dakota No. 9 for its Talent Pipeline, noting our low tuition rates and our No. 2 ranking in the percentage of individuals with an associate's degree or higher. The report also noted that to support the overwhelming demand for oil and gas workers, the state has established a Petroleum Safety and Technology Center at Williston State College to provide workforce training.

The same report ranked North Dakota No. 3 in Academic R&D Intensity, calculated as academic R&D funding as a percentage of Gross State Product. It should be noted, however, that in absolute terms, North Dakota ranks very low nationally (due to its small population): 41st in academic R&D and 48th in total R&D performance in 2007, according to the National Science Foundation.[11] In specific areas of research, the state does somewhat better in federal research funding rankings: No. 22 for Department of Agriculture; No. 28 for Department of Energy; No. 29 for the Environmental Protection Agency in 2007 (the latest data available). These rankings may have changed significantly since the discontinuance of federal "earmarking" in FY2010.

North Dakota is one of 28 EPSCoR states designated by NSF; the EPSCoR program is directed at those jurisdictions that have historically received lesser amounts of NSF Research and Development (R&D) funding. It is designed to create sustainable improvements in a state's research infrastructure and R&D capacity, with the goal of increasing the state's national R&D competitiveness. North Dakota has been continuously funded by the NSF EPSCoR program since 1985, and has enjoyed strong support in the form of matching funds appropriated by the state.

Science and Technology Employment

North Dakota Job Services listed the top 25 fastest-growing occupations (by percentage change in jobs) as of June 2012.[12] At the top of the list is Petroleum Engineers, with a projected annual growth of 6.4 percent from 2008 to 2018. Also in the top 10 are Network Systems and Data Communication Analysts, Medical Scientists, and Geological and Petroleum Technicians, all of which are S&T jobs. Computer Software Engineers and Pharmacy Technicians are also in the top 25.

Oil and Gas Extraction, heavily dependent on science and technology, is the fastest-growing industry in North Dakota, with a projected growth rate of 4.5 percent per year from 2008 to 2018.[13] Chemical manufacturing is projected to be the fourth fastest-growing industry in the state during this time period. Professional, Scientific, and Technical Services also made the Top 25 list of fastest-growing industries.

Research Funding at the State's Two Research Universities

Shortly after the higher education Roundtable report[14] in 2000, a challenge was issued to North Dakota State University and the University of North Dakota to increase their research funding to $100 million a year in new grants and awards. The Roundtable report noted that the "research foundation on which entrepreneurial activity will necessarily be based must be expanded."

The strategic plan developed under UND President Charles Kupchella in 2000 explicitly stated as goals to "increase externally supported research and development and other externally funded activity to the level of $100 million annually by 2006," and "UND achieves $100 million in annual external funding ($80 million for research), 2006."[15] In FY2000, external grants and contracts at UND totaled $41.6 million, and by FY2006, had increased to $82.9 million. External funding hit an all-time high of $127.9 million in FY2010, and then fell to $98.6 million in FY2011, after the end of federal "earmarks." UND's ability to reach this goal as quickly as it did was undoubtedly aided by earmarks, which peaked at $39.9 million in FY2010. That these earmarks helped to build research capacity and competitiveness can be inferred from FY2012 grants and contracts that totaled $87million. Grant expenditures are frequently used as an index of activity as well, since a grant is awarded in one year, but funds are typically spent over two or three years. UND's research expenditures have exceeded $100 million a year since FY2010.

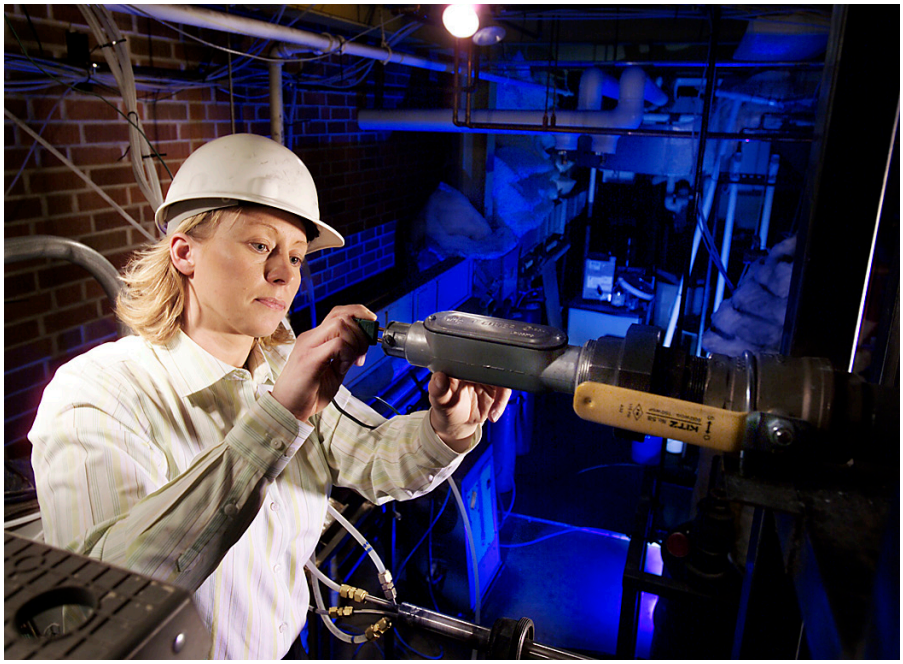
NDSU experienced similar increases in external funding, including federal appropriations, achieving $112 million in external dollars for FY2011. Research spending at NDSU has consistently been above $100 million annually since 2004. In 2011, NDSU was designated by the Carnegie Commission on Higher Education in the category of Research Universities/Very High Research Activity.

The challenge for the future will be for North Dakota's two research universities to remain competitive for what is predicted to be an increasingly smaller pot of federal research funds.

STEM Education in North Dakota

The federal Department of Education lists teacher shortages for math and science in North Dakota for 2011-2012 and 2012-2013.[16] According to Job Services North Dakota, the state produced 36 bachelor's-level math teachers in 2010, and 22 science teachers, of whom 14 were biology teachers, one chemistry, and one physics.[17] In 2006, 79 percent of math teachers in North Dakota had math as their main assignment, while 42 percent of biology teachers had biology as their main assignment, 16 percent of chemistry teachers had chemistry as their main assignment, and only 4 percent of physics teachers had physics as their main assignment.[18] To some degree this may reflect the number of rural schools in North Dakota that do not have large enough enrollments to hire separate teachers for each area of science. However, the paucity of students seeking degrees in chemistry and physics teaching, compared to the fact that there are about 165 teachers for high school chemistry and 114 for physics,[19] seems to indicate that the state is not producing enough high school teachers with solid backgrounds in chemistry and physics.

Despite this, the state graduated more than 460 baccalaureate-degree engineers in 2010, and awarded 511 bachelor's degrees in other STEM areas, not including math. Biology was the most popular undergraduate major (138 degrees). There were 35 doctorates awarded in the life and physical sciences, of which 40 percent were in chemistry.



S&T Employment in North Dakota

As of May 2012, North Dakota's unemployment rate was 3.0 percent.[20] Total nonfarm employment had increased by 6.8 percent in the previous 12 months. In the Mining and Logging sector, which included the state's oil and gas industry, employment increased 42.9 percent since May 2011, adding 3,700 jobs. Manufacturing increased 3.8 percent. The only sector showing a decrease in employment between May 2011 and May 2012 was government, with a drop of 0.8 percent (about 300 jobs). Job Service North Dakota reported that in June 2012, there were 22,895 online job openings listed in the state, and that the state had 0.5 unemployed people per job opening. In the Williston basin there were as few as 0.1 unemployed persons per job opening. In the computer and mathematical occupational group, there were 0.4 active resumes per opening; in architecture and engineering, 0.2; and in life, physical and social sciences, 0.6.[21]

The North Dakota Economy

It is no secret that North Dakota leads the nation in economic growth. The Gross State Product grew by 7.63 percent from 2010 to 2011.[22] State budget reserves are projected to hit $2 billion by June 2013.[23]

STRATEGIES

1. Focus research and development in areas that are already strengths in the state so that North Dakota can continue to increase its competitive advantage.

A. Energy

As pointed out above, the oil and gas industry is the fastest-growing sector of the economy in North Dakota. There are many unanswered questions about the environmental impacts of "fracking," and concern about whether the federal Environmental Protection Agency will regulate fracking at the national level. Other research opportunities related to oil and gas abound, including improved oil recovery, geothermal energy capture, and CO_2 storage. The state's abundant coal resources provide much of our electric power, yet coal usage is under attack nationally on environmental grounds; this creates some obvious targets for research. North Dakota has the sixth-largest wind resource in the nation and could provide nearly 240 times the state's electricity needs,[24] but wind is an intermittent resource; thus, the need for better energy storage in batteries or by other means continues to be an important challenge. Development of diverse energy resources also impacts wildlife and ecosystems; this presents a potential negative impact on hunting and fishing, which undergird much of the state's tourism industry, warranting further research on optimal management of wildlife resources.

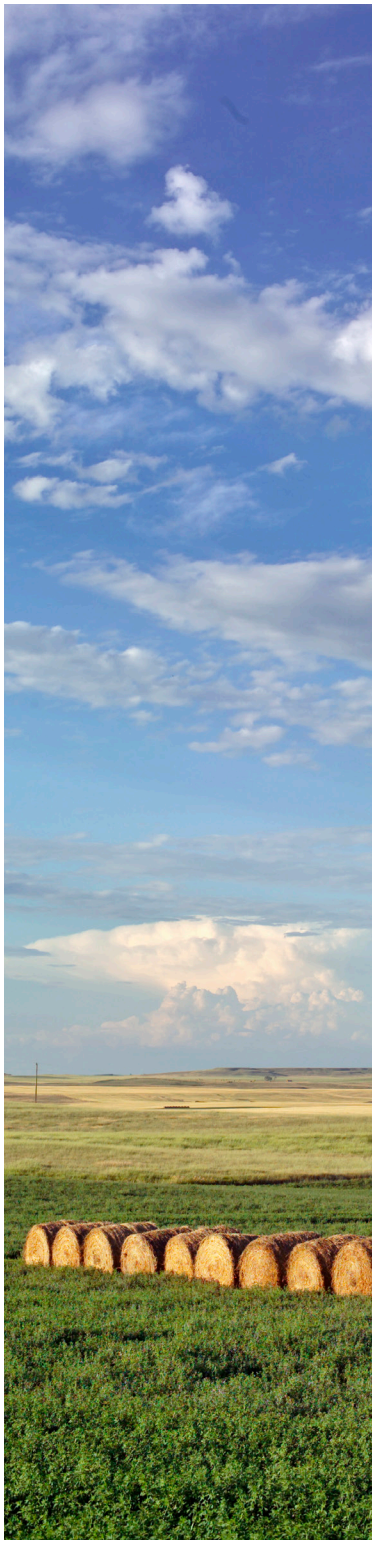
B. Aerospace, especially unmanned aircraft systems

The University of North Dakota offers a comprehensive education in aviation, with technologically advanced simulators and the world's largest collegiate training fleet. In recent years, the aviation program has expanded to include Unmanned Aircraft Systems (UAS), also known as Remotely Piloted Aircraft (RPAs). Research concerning UAS includes NDSU as well as NDSU. The Grand Forks Air Force Base is home to unmanned aircraft operated by both the Air Force and Customs and Border Patrol, and the North Dakota Air National Guard also operate unmanned aircraft from its base in Fargo. The concentration of activity related to UAS has resulted in related businesses locating in Grand Forks. The state's Airspace Integration Team, appointed by Governor

Dalrymple, is preparing a proposal that is expected to lead to North Dakota being designated as one of six UAS National Test Sites by the Federal Aviation Administration in late 2012. To date, UAS-related efforts have produced approximately 250 jobs and positioned North Dakota as a recognized leader in the industry. In looking at the future, conservative estimates put the economic benefit to North Dakota of securing a test site at $213 million over the next 10 years. The size of the national UAS market is projected to reach $7.3 billion in 2012,[25] and is expected to grow substantially after the FAA issues regulations allowing unmanned aircraft to be flown in the National Airspace alongside conventional aircraft; the FAA has been directed to do so by 2015. This represents a significant economic opportunity for the state. Both research universities are involved in research that will lead to new commercial and scientific applications of UASs beyond the current military applications.

C. Agriculture, including development of biofuels and sustainable materials of all kinds

Agriculture is a critical part of the North Dakota economy, with more than $6 billion in total agricultural products sold in 2007.[26] North Dakota ranks second nationally in wheat production nationally, first in barley production, and ninth for soybeans. As much as a third of the nation's edible dry beans are produced here.[27] Cattle production is also a major sector of North Dakota agriculture.



NDSU's plant scientists conduct research to increase productivity of crops as well as resistance to pests of all kinds. A state-of-the-art greenhouse gives NDSU plant scientists a research platform without parallel in North America. A new research partnership with Australia's Department of Primary Industries will accelerate development of new and improved varieties of cereals, grains, and legumes with higher productivity and improved adaptability to benefit producers in North Dakota. The new Beef Cattle Research Complex at NDSU is only one of three such facilities in North America. This state-of-the-art facility enables advanced research in beef cattle genetics, nutrition, reproduction and physiology, feed efficiency, and meat quality.

NDSU's soil health initiative is focused on research and Extension activities to address soil salinity, management, fertility, tillage, drainage, and other factors. These go beyond traditional agricultural research: NDSU is performing research to develop solutions for brine spill contamination in oil-producing areas of western North Dakota.

Weather is a concern for all agricultural producers. NDSU's innovative NDAWN (North Dakota Agricultural Weather Network) system continues to aid many producers in the state as they make weather-critical decisions. Research at UND on both satellite-based remote sensing and on moving agricultural remote sensing applications to unmanned aircraft also holds promise for North Dakota agriculture.

Research on value-added agriculture and non-food uses for agricultural products continues to be important as an avenue for diversification of agricultural income streams. NDSU and UND both conduct research and development related to generation and use of biofuels. This work includes development of biodiesel from soybeans, canola, and animal fat. Continued support of research on improving the "cracking" reactions used to turn these materials into fuels and other valuable products could make biofuel production more profitable. NDSU is also conducting research on the feasibility and agronomic potential of raising "energy" beets for ethanol production. If research results continue to be positive, the private sector is considering construction of a commercial plant sometime in 2013. Promoters of "energy" beets envision building as many as 12 commercial facilities in North Dakota. Development of composite materials from materials such as flax fiber and corn stover, as well as production of other bio-based materials for making pharmaceuticals and other commercial chemicals, also hold promise for creation of new business in the state. The opening of the Ultra Green wheat straw fiber processing plant in Devils Lake[28] to produce environmentally friendly products, with a potential payroll of nearly $4 million in 2013, is an example of the potential downstream benefit from such research.

North Dakota is also fortunate to have two USDA research facilities that address a variety of agricultural issues. The Fargo USDA labs work on weeds, insects, integrated pest management, improvement of wheat, barley, oats, potatoes, and sunflower germplasm and production methods. They also carry out research on the negative impacts of foreign chemicals in food animals and food processing. The Mandan lab has a mission to develop economically and environmentally sustainable integrated crop and livestock management systems to help preserve the family farm.

D. Life sciences

Life sciences research in the state centers on two main themes: agriculture, addressed above, and biomedical research. Biomedical research is concentrated in the School of Medicine and Health Sciences at UND, the College of Pharmacy at NDSU, and the USDA's Grand Forks Human Nutrition Research Center, which focuses on human nutrition, particularly obesity.

NDSU and UND have received more than $52 million in NIH funding for research in visual and cognitive neuroscience and neurodegenerative diseases. North Dakotans tend to live longer than people in many other states and thus have a relatively high incidence of neurodegenerative disease such as Parkinson's and Alzheimer's, making neuroscience a natural research focus for the state. Both universities also conduct research on cancer, arthritis, autoimmune diseases, diabetes, and

asthma. At NDSU, new antimicrobial and biodefensive polymers and coatings (originally developed to reduce or prevent biofouling on ships) are being evaluated for use on biomedical devices to reduce or eliminate infections.

Research and development on new biopharmaceuticals such as improved vaccines is growing in the Red River Valley, and includes both university and private sector companies such as PRACS, NovaDigm, Avianax, and Aldevron. The Centers of Excellence program has facilitated growth of the private sector in this area. Continued support of R&D focused on infectious disease will build on existing expertise and business activity.

E. Water quantity and quality

Chronic flooding in the Devils Lake area that began in the 1990s has inundated hundreds of homes and businesses and thousands of acres of farmland. Catastrophic river floods on the Red River, Souris River, and Missouri River have created serious challenges for major communities and small towns alike throughout the state. Although the state has been in a wet cycle for the past two decades, historically a lack of water for agricultural production has also been a challenge, and 2012 was a time of serious drought in much of the state. Current oil development in the western part of the state has also raised questions about environmental impacts and potential water pollution.

F. Advanced manufacturing

Microelectronics, avionics, embedded systems, and related technologies — NDSU and UND offer expertise, experience, and facilities for research, development, and low-volume prototype manufacturing of sensors, wireless electronics, electronic miniaturization, chip scale packaging, and surface mount technology. These capabilities are uniquely combined with other R&D at NDSU on polymeric materials, coatings, conductive inks, and other materials to produce technologies that enhance the advanced manufacturing industry cluster in North Dakota. University faculty, staff, and students partner with government agencies and the private sector to develop, test, and deliver new microelectronics, avionics, embedded systems, and related technologies.

Advanced Materials and related technologies — NDSU has a long-standing, worldwide reputation for research and development of advanced materials such as polymer, coatings, and specialty chemicals. NDSU's Department of Coatings and Polymeric Materials has been engaged in coatings research and development and education in these areas for over 100 years. Beginning with research on paints derived from renewable crop oils (e.g., linseed oil from flax), these research and development efforts have yielded advanced technologies for protecting metals from corrosion, preventing biological fouling on ships, preventing biological contamination of fabrics and other materials, and improving the effectiveness of various biomedical devices. Such technologies and intellectual property have been

optioned and/or licensed to some of the largest coating companies in the world. Several of these companies are working with a Centers of Excellence program to further refine and test such coating systems, thereby leading to improved manufacturability and performance of highly valuable products for various global competitive markets, e.g., aerospace, marine, biomedicine, etc. Since NDSU has the largest automated, combinatorial chemistry laboratory for polymers and coatings, companies involved in the advanced manufacturing of such products are coming to North Dakota to engage in collaborative research. Indeed, some companies have established new research and development programs in North Dakota so they can work more closely with NDSU.

Both research universities are developing novel technologies that allow oils and other chemicals derived from renewable crops to be used as chemical feedstocks for making new plastics and polymers, as well as pharmaceuticals and other economically significant materials. A significant amount of petroleum is now used to make such plastics and related polymers, so using crops as a source of chemical feedstocks permits petroleum to be used for other purposes. These "green" technologies provide a cost-effective means to produce high gross margin chemicals from renewable crops grown in North Dakota.

NDSU has also pioneered in the research and development of new and novel silane-based materials that can be used as "electronic inks" in manufacturing a variety of next-generation products such as electronics, batteries, etc. These cyclohexasilane-based "inks" can be used to manufacture printable or flexible microelectronics, more efficient and cost-effective solar cells, and high-performance, long-lasting batteries.

2. Support and expand the infrastructure for research, particularly at the two research universities.

A. Continue to provide state funding as a match for federally funded capacity-building programs such as NSF EPSCoR and the NIH IDeA programs.

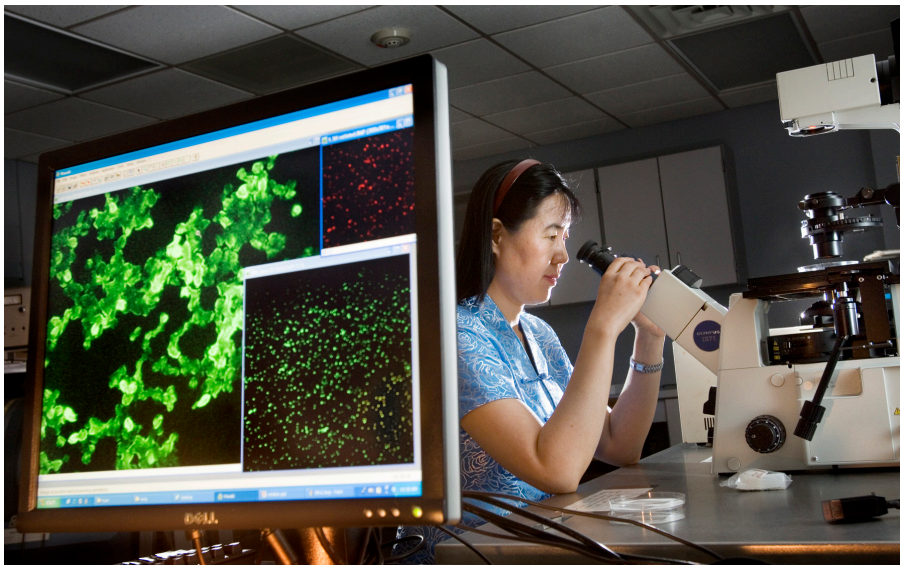
The National Science Foundation's EPSCoR Program (Experimental Program to Stimulate Competitive Research) and the National Institutes of Health IDeA Program (Institutional Development Award) and similar federal programs provide funding that has been critical in building research capacity at the state's two research universities and in

assisting their outreach and collaboration with four-year institutions in the North Dakota University System and with the state's tribal colleges. Grants are awarded on a state-level basis and managed jointly by UND and NDSU. The North Dakota Legislature has supported these programs through state funding since 1986, most recently at the level of $7 million for the 2011-2013 biennium. This funding has provided strong evidence of state support for research, and has been critical to enhancing North Dakota's competitiveness for these federal programs. Between 1986 and 2010, the state's investment of $32.5 million in matching federal EPSCoR funding resulted in over $264 million in merit-based extramural grants at UND and NDSU—an 8:1 return on investment29.

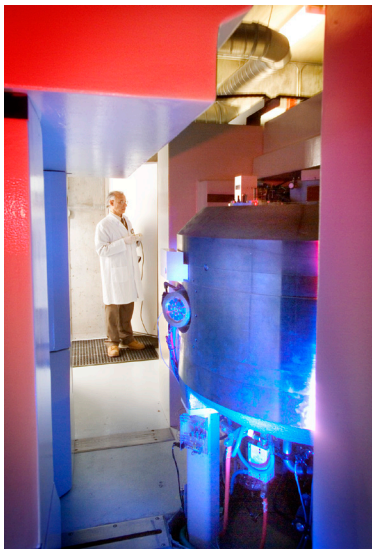
Specifically, with respect to Cornerstone 1: The Economic Development Connection, the North Dakota Higher Education Roundtable Report states, "The research foundation on which entrepreneurial activity will necessarily be based must be expanded...To this end, the state should maximize the opportunities of EPSCoR funding available through Congress to assist in developing research and technology infrastructure..."

B. Provide resources to hire additional highly qualified faculty in the areas identified above (faculty lines, recruitment packages).

Doctoral-level faculty are recruited from a national pool, so North Dakota's universities compete with many other institutions as they



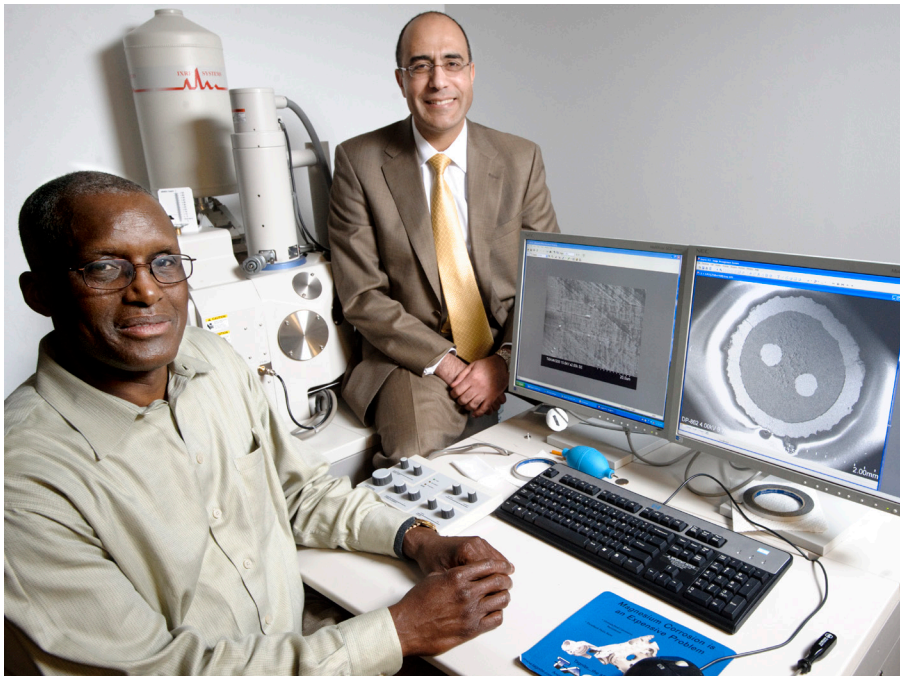
seek to hire outstanding faculty. When universities recruit new faculty for positions in science and engineering, they need to offer start-up packages that allow the faculty to equip labs and carry out research during the first year or two when they are applying for external competitive funding (external grants always require preliminary data as evidence that a proposal is a good idea). Such start-up funding can range from $100,000 to as much as $1 million, depending on the area of research and the accomplishments of the person being recruited. While NSF EPSCoR grants provide funds to supplement start-up packages, costs to hire outstanding faculty have increased beyond the level where EPSCoR funding is sufficient. Moreover, EPSCoR can only fund start-up packages for faculty working in areas for which NSF gives grants; positions in UND's School of Medicine and Health Sciences and NDSU's College of Pharmacy are often not eligible for EPSCoR start-up funds, yet start-up packages in the biomedical sciences tend to be the largest nationally. Adequacy of start-up funds is a critical factor for UND and NDSU to compete in a national labor pool for the best faculty.



C. Support research programs by providing modern physical facilities, modern equipment, and critical mass of technicians and other support personnel.

Research infrastructure consists of physical resources, including buildings to house research labs and the people doing the work, research lab spaces, instrument core facilities and information technology, as well as human resources such as graduate and undergraduate students, postdoctoral research scientists, technical research assistants, support staff to administer grant applications and compliance with granting agency regulations, department administrators to manage grant expenditures, and legal consultants to manage intellectual property and commercialization.

The absence of new state-funded construction and maintenance of research buildings at UND and NDSU has stretched physical resources to the limit in many departments. Many campus research spaces were constructed in the 1970s and 1980s, or earlier, and are in need of substantial renovation to provide casework, electrical and water service, safety cabinets, lighting, heating and cooling to support the equipment and activities associated with state-of-the-art research. As a result, new faculty members often commit a large proportion of start-up funds toward such building infrastructure at the cost of purchasing needed equipment or hiring students and staff to do the work. Furthermore, although several instrument core facilities are now

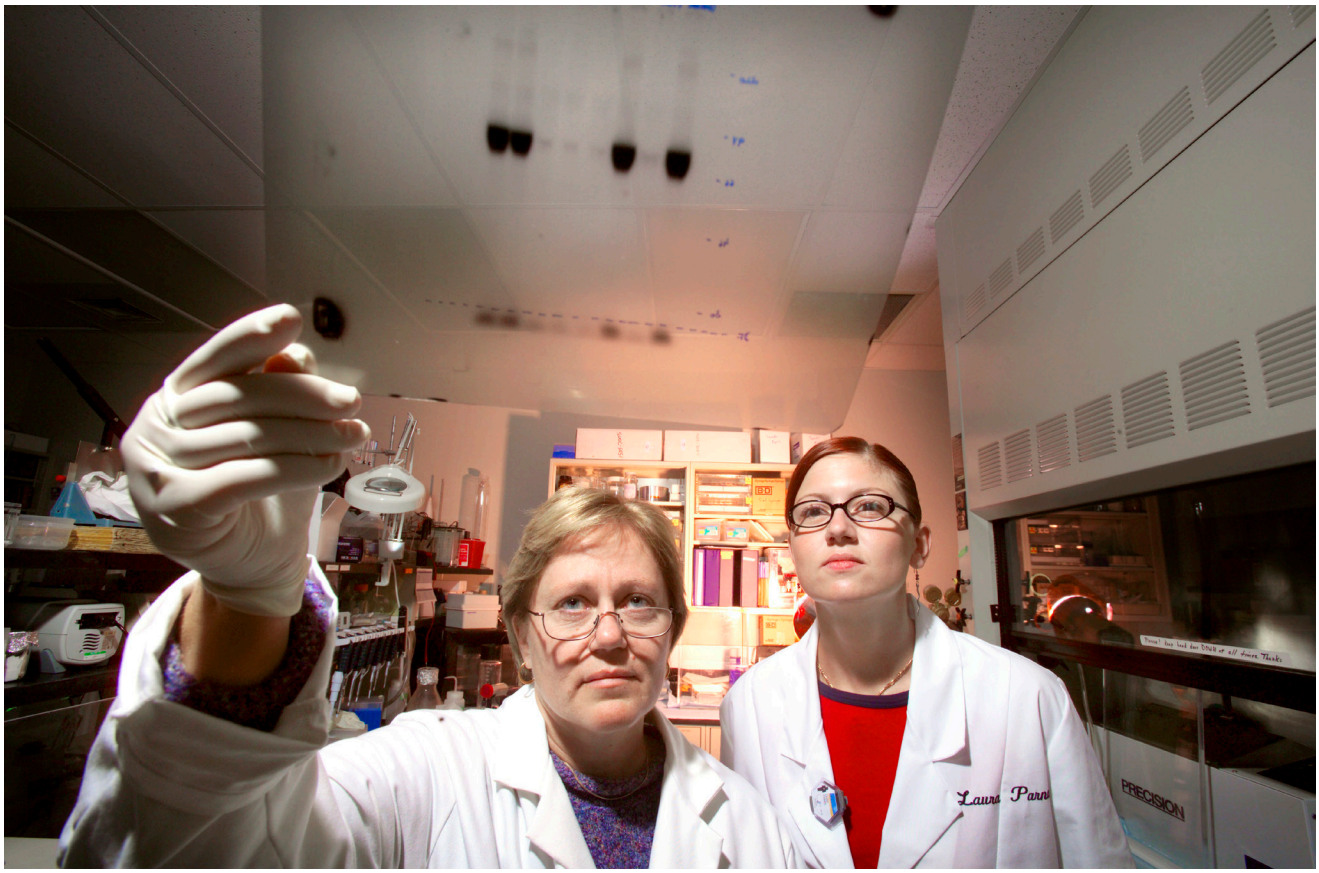


available on campus, UND still lags behind major research universities. These facilities provide shared access to essential equipment that might otherwise be too expensive for individual researchers to purchase. Research universities generally provide core equipment and fund both its maintenance costs and permanent support staff to operate these sophisticated instruments. In addition, granting agencies consider the availability of such communal research equipment when reviewing the competitiveness of grant applications from individual scientists.

The portion of sponsored funding that returns "F&A" (facilities and administration) dollars (also known as indirect costs) to the institution is critical in supporting both the administration of research and the facilities in which it takes place. The amount of F&A funding is based on the prior year's grants. These funds are normally associated only with federal grants; the state does not pay F&A. In FY 2011, UND received about $18 million in F&A funds, much of which covers administrative overhead, but which is also distributed to deans, departments, and faculty. The maximum F&A rate that the academic portion of UND receives on federal grants is 38 percent of the direct research costs; this is believed to be the lowest rate in the nation. The rate at NDSU is 45 percent. The F&A rate depends significantly on the amount of research space at a university; space constructed with federal funds, while valuable because universities need modern

facilities to do their work, does not count in the space calculation that determines the federal F&A rate. Research facilities that are more than 20 years old are considered to be fully depreciated and do not count in the space calculation to determine F&A. Most research universities receive much higher F&A rates (rates of 60 percent or more are not uncommon) on federal grants than UND and NDSU; the average F&A rate nationally is about 51 percent.[30]

While research grants sometimes provide funding to hire laboratory technicians, postdoctoral fellows, or other staff, some critically needed human resources cannot be funded by federal grants. For example, UND has less than half the number of administrative staff at the department level to help scientists manage grants than comparable research institution. This means that the University ends up paying Ph.D.s to do bookkeeping and other administrative tasks, at the expense of devoting more time to research. Such administrative support is normally funded at the institutional level, often from F&A funds. Most research universities also support some permanent technical staff,



at least for core research facilities. For example, the University of Kentucky (a peer/aspirant institution) has 19 staff and 35 faculty in its chemistry department; UND has 3.75 staff for 15 faculty in Chemistry. The lack of such administrative and technical support is an important constraint on UND's research productivity.

Indeed, a recent national survey[31, 32] found that of the time that faculty committed to federal research, 42 percent was devoted to pre- and post-award administrative activities — not to active research. Sixty-five percent of the respondents believed that they could devote at least two additional hours each week to active research if they had more assistance with administrative tasks. Given the limited support staff at UND, the research program would realize even greater than average gains in productivity if staff support were increased.

3. Support technology transfer and, where appropriate, commercialization of inventions and innovations developed by universities.

The research enterprise at the state's universities provides benefit to the state beyond the jobs created and the new information that is generated and published. The ability to create and develop intellectual property (IP) and transfer it to the private sector for development is a huge benefit to the state and the nation.[33, 34] Technology transfer helps change and improve lives, creates jobs, and is necessary for our country to stay competitive in a changing world. It is vital to support these offices so they are appropriately staffed, have resources to file patents on the best discoveries, and are able to license the best research discoveries to companies so they can develop products. When these efforts are successful, IP offices can reinvest the royalty rewards to further their important work.

The state of North Dakota needs to support the technology transfer operations at both of its major research universities to ensure the level of professional management required to harness the IP created at each. This includes budgetary support for IP professionals, budgets for patent filings and similar costs, and professional development. Another needed tool is resources for IP offices to be able to spot-fund those inventions with the most commercial potential across the "valley of death" (between where traditional academic funding stops and commercial development funding starts).

4. Foster partnerships between the private sector and research universities.

Perhaps the most difficult aspect of commercializing a university's intellectual property is making the match between the IP itself and an entity (established or a start-up) that is committed to making it happen. Programs that foster partnerships between the private sector and the two major research universities in North Dakota are necessary to realize the full potential of technology we decide to pursue. In particular, the North Dakota Centers of Excellence program, which provides grant funding to projects where a research University has identified and sought out a commercial partner, is extremely important.[35] In addition to the COE program, the federal SBIR and STTR programs are important for funding small companies to develop technology from universities. North Dakota's support of a statewide SBIR/STTR resource, currently located at the Center for Innovation at UND, for both small companies and universities, is a wise investment that facilitates our taking advantage of these important programs.[36]

Research and technology parks and technology incubators have developed into important organizations for enabling university and business communities to collaborate and develop innovation-driven partnerships. These endeavors have created new economic opportunities, including creation of high-technology jobs.

For example, in 1999, the NDSU Research and Technology Park, Inc. (RTP, a private, 501(c)(3) nonprofit corporation) was established to provide a place where university researchers and private industry can combine talents to develop new technologies, methods, and systems. In a few short years, the RTP grew to a development with seven buildings and 893 direct on-site jobs. In 2006, the U.S. Department of Commerce recognized the NDSU RTP as "Best" in the Nation for Technology-based Economic Development. According to a 2011 analysis by an independent economic impact firm, the NDSU RTP has positively impacted economies, contributed to job creation efforts, and helped generate more than $10.9 million in revenue annually for local and state governments. The NDSU Research and Technology Park's Incubator, an innovation accelerator for technology-based entrepreneurs and businesses, opened in April 2007. Clients in the Technology Incubator have business interests in areas such as materials sciences, biosciences/life science technology, information technology, nanotechnology, and advanced manufacturing/microelectronics. At UND, the Skalicky Incubator at the Center for Innovation and the REAC Technology Accelerator serve the same functions as their counterparts at NDSU.

5. Find ways to produce, hire, and retain more high school-level STEM teachers (a shortage occupation in the state), especially for small rural schools.

Expand the program for student loan repayment for STEM teachers in the state.

Funds for upgrading science labs and facilities in schools would allow more students to be exposed to modern science and to experience how data is collected and analyzed. Science teachers, like other professionals, will be more effective if they have up-to-date resources to work with.

Attendance at National Science Teacher Association (NSTA) conferences, which are held yearly, will introduce teachers to new technology and teaching methods. A mechanism for funding teachers' attendance at these meetings is needed. Industries spend a great deal of money to keep their technical employees up to date in order to be competitive, but schools often expect teachers to be up to date with no outside contacts or additional training. It is cost-effective in terms of job satisfaction and improvement of science teaching to send science teachers to such conferences. Teachers will be more likely to stay in North Dakota and build the future for their students if they are provided with professional incentives.

Conducting science demonstrations in the classroom, especially at the high school level, helps get students excited about science. This approach creates an atmosphere of problem solving and inquiry at all levels of education. Training in how to conduct such demonstrations, as well as opportunities to obtain funding for needed materials, would be motivational for teachers.

Funding for Science Fair Improvement Workshops to train teachers how to prepare students to do research projects would also be helpful. Teachers would benefit from professional contact with university researchers and an improved understanding of how research is done. Many university faculty advise students in developing research projects for science fair competitions, and even provide access to laboratory equipment to advanced students. However, students need to understand what research involves and how it is done before they can begin even fairly simple independent projects. Teachers sometimes require a science project of students and approach this in a way that leads some students to do "cookbook" projects that are not original, thus largely defeating the purpose of a science fair project. Teacher workshops could lead to significant improvements in this area.

6. Increase state investment in research at the institutions in the North Dakota University System.

On the national level, state funding for higher education has been declining for decades, and the recession that began in 2008 exacerbated this trend. During this time, North Dakota's economy has prospered, and appropriations per full-time student have increased. Over the past five years, the percentage change in appropriations/full-time student has ranged from more than a 30 percent decrease in South Carolina to an increase of about 18 percent in North Dakota.[37] The National Research Council recently released a Congressionally requested report that characterizes the nation's research universities as key to the nation's prosperity and security.[38] One of its 10 recommendations is that states invest in research and research universities. North Dakota's excellent economy offers an opportunity to make such investments, potentially also allowing UND and NDSU to pull ahead of their competitors at the same time their innovations benefit the state.

7. Create ways to increase awareness of the S&T capacity of the state, and to use it to develop regulatory schemes based on sound science.

Consider means of recognition for achievement in science and technology to reward desired outcomes. Some states give awards for achievement in both higher education and the private sector. This need not involve great expense, but a presentation of a plaque or medal by the Governor, accompanied by appropriate publicity, would show that the state values achievement in science and technology.

The need for states to regulate a variety of activities in ways that protect public health and safety and the environment begs for mechanisms to support regulatory activities with sound science. The creation of a State Science and Technology Commission to provide expertise and guidance on an ongoing basis could provide sound scientific and technical advice in diverse areas of science and technology. Much of the needed expertise might be found in the state's two research universities, which could provide faculty experts without the potential conflicts of interest that would arise from involving private-sector people in such an enterprise.

Some states have also established the position of Science Advisor to the Governor and/or legislature; in some states this is a permanent, full-time position. Such an individual could chair a State Science and Technology Commission. In the absence of a Commission, the Science Advisor could seek ad hoc assistance as needed from subject matter experts.

CONCLUSION

North Dakota's economy is booming. Energy has only recently become a major sector of the state's economy; agriculture is still the largest economic sector. Other areas such as Unmanned Aircraft Systems are emerging. All depend greatly on modern science and technology, as do many of the needed solutions to environmental issues. It behooves the state to pay attention to these matters in order to foster a robust 21st century economy.

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List of Acronyms

COE	Center of Excellence
CORE	Center of Research Excellence
DOE	Department of Energy (federal)
EDF	Economic Development Foundation (North Dakota)
EPSCoR	Experimental Program to Stimulate Competitive Research (federal, several agencies)
F & A	Facilities & Administration (overhead costs on federal grants)
FAA	Federal Aviation Administration
IDeA	Institutional Development Award (similar to EPSCoR)
IP	Intellectual Property
NDSU	North Dakota State University
NDUS	North Dakota University System
NIH	National Institutes of Health (federal)
NSF	National Science Foundation (federal)
R&D	Research and Development
RPA	Remotely Piloted Aircraft
RTP	Research and Technology Park (NDSU)
S&T	Science and technology
SBIR	Small Business Innovative Research Grant
STEM	Science, Technology, Engineering, and Math
STTR	Small Technology Transfer Research Grant
UAS	Unmanned Aircraft System (equivalent to RPA)
UND	University of North Dakota
USDA	United States Department of Agriculture

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July 19, 2013

Phyllis Johnson, PhD
Vice President of Research and Economic Development
University of North Dakota
Twamley Hall, Room 103
264 Centennial Drive, Stop 8367
Grand Forks, ND 58202

Dear Vice President Johnson:

North Dakota's future, as defined in our strategic planning documents, relies heavily on increasing the State's strengths in the areas of STEM. The Governor and State Legislature have both acknowledged the importance of STEM related industries and occupations as critical for our continued growth.

The supplied *North Dakota: "Undiscovered Hotspot for Science- and Technology-Based Development" A Strategic Plan for Science and Technology in North Dakota* succinctly brings together the strategies related to science, technology, engineering and mathematics that have been have identified in recent state, industry, and education strategic planning sessions.

I am happy to report that progress is being made toward the goals outlined in this strategic plan.

- Energy and agriculture continue to be areas of strong economic activity and research across the state with state supported grant programs like the Agricultural Products Utilization Commission and Renewable Energy Council providing financial support for research in these areas.
- The North Dakota Legislature continued its support of aviation, specifically Unmanned Aerial Systems, through the designation of an additional $1 million for costs associated with North Dakota attaining designation by the Federal Aviation Administration as an Unmanned Aircraft Systems Test Site along with $4 million to assist in the operation of this site.
- A new state funded grant program to North Dakota's research universities to support research, development and commercialization activities in conjunction with the private sector.
- Monies were appropriated to continue to support the universities through state matching funds for the federal capacity building like the NSF EPSCoR program and infrastructure improvements to university libraries and University of North Dakota Medical School.

The largest statewide strategic planning session, *2020 and Beyond;* was designed to prepare the State for ongoing economic and community development. A key point that was brought out in this report is that North Dakota ranks first in science, technology, engineering and math (STEM) occupation job growth since 2001, but ranks 45th in overall concentration of STEM occupations in the US. As more of North Dakota's new job creation is related to STEM occupations, continuing to move down the path outlined in these strategic plans will be paramount.

The success of the University of North Dakota and North Dakota State University in competing for EPSCoR funding have aided our efforts to diversify North Dakota's economy and helped provide a skilled workforce for our STEM industries.

Sincerely,

Alan R. Anderson
Commissioner